RECOMMENDED PRACTICE FOR PORTLAND CEMENT STUCCO

LEHIGH CEMENT

LEHIGH PORTLAND
CEMENT COMPANY
ALLENTOWN, PA. CHICAGO, ILL.
SPOKANE, WN.

WHAT Portland Cement Stucco did for the old house shown below

Recommended Practice for Portland Cement Stucco

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STANDARD RECOMMENDED PRACTICE FOR PORTLAND CEMENT STUCCO*

General Requirements

1. *Design.*—Whenever the design of the structure permits, an overhanging roof or similar projection is recommended to afford protection to the stucco. Stuccoed copings, cornices and other exposed horizontal surfaces should be avoided whenever possible. All exposed stuccoed surfaces should shed water quickly, and whenever departure from the vertical is necessary, as at water tables, belt courses, and the like, the greatest possible slope should be detailed. Stucco should not be run to the ground whenever other treatment is possible. Should the design of the structure require this treatment, the backing should be of tile, brick, stone, or concrete, providing good mechanical bond for the stucco, and should be thoroughly cleaned before plastering. Unless special care is taken to thoroughly clean the base and each plaster coat from dirt and splash before the succeeding coat is applied, failure of the stucco may be expected.

2. *Flashing.*—Suitable flashing should be provided over all door and window openings wherever projecting wood trim occurs. Wall copings, cornices, rails, chimney caps, etc., should be built of concrete, stone, terra cotta, or metal with ample overhanging drip groove or lip, and water-tight joints. If copings are set in blocks with mortar joints, continuous flashing should extend across the wall below the coping and project beyond and form an inconspicuous lip over the upper edge of the stucco. Continuous flashing with similar projecting lip should be provided under brick sills. This flashing should be so installed as to insure absolute protection against interior leakage. Cornices set with mortar joint should be provided with flashing over the top. Sills should project well from the face of the stucco and be provided with drip grooves or flashing as described above for brick sills. Sills should also be provided with stools or jamb seats to insure wash of water over the face and not over the ends. Special attention should be given to the design of gutters and down spouts at returns of porch roofs where overflow will result in discoloration and cracking. A 2-inch strip should be provided at the intersection of walls and sloping roofs and flashing extended up and over it, the stucco being brought down to the top of the strip.

3. *Preparation of Original Surface.*—All roof gutters should be fixed, and downspout hangers and all other fixed supports should be put in place before the plastering is done, in order to avoid breaks in the stucco.

Metal lath and wood lath should be stopped not less than 6 inches above grade to be free from ground moisture.

All trim should be placed in such manner that it will show its proper projection in relation to the finished stucco surface, particularly in overcoating.

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*Adopted by letter ballot of the Institute, April 17, 1920.

The notes appearing on successive right-hand pages apply to the respective left-hand page of the "Recommended Practice." Both the "Recommended Practice" and the notes were prepared by the Committee on Treatment of Concrete Surfaces.

Successful stucco work depends in large measure upon suitable design of the structure *for stucco.* Exterior plaster of any kind merits whatever protection can legitimately be given it, and while concession must sometimes be made to architectural requirements, there is rarely any necessity for subjecting stucco to an exposure which it cannot reasonably be expected to withstand. Even where stucco will remain structurally sound, it is sometimes wiser to use other treatment for the sake of appearance. For example, it is better not to run stucco to grade, not only because of the danger from frost action, but also to avoid staining of the stucco from dirt and moisture. For the same reason special attention should be given to details of flashing and drips, wherein a little foresight will prevent much unsightly discoloration, and possibly more serious defects.

A fundamental rule in the design of a stucco structure is "Keep water from getting behind the stucco." The architect should go even further than this and endeavor to keep any concentration of water flow from getting at the stucco at all. Real study of methods of avoiding damaging leaks and drips and of providing properly for roof drainage will be well repaid.

Paragraphs 1 to 3 contain definite suggestions for stucco protection. These are supplemented herewith by the simple drawings which show typical details for such protection.

MASONRY WALLS

4. *Tile.*—Tile for exterior walls should preferably be not less than 8 inches thick, and should be hard-burned, with dovetail or heavy ragged scoring. Tile should be set in cement mortar composed of one part cement, not more than one-fifth part hydrated lime and three parts sand, by volume. The blocks should not vary more than ½ inch in total thickness and should be set with exterior faces in line. Joints should not be raked, but mortar should be cut back to surface. Neither wire mesh nor waterproofing of any type should be applied to tile walls before plastering. The surface of the tile should be brushed free from all dirt, dust and loose particles, and should be wetted to such a degree that water will not be rapidly absorbed from the plaster, but not to such a degree that water will remain standing on the surface when the plaster is applied.

5. *Brick.*—Surface brick should be rough, hard-burned, commonly known as arch brick. Brick should be set in cement mortar with joints not less than ⅜ inch thick, and the mortar should be raked out for at least ½ inch from the face. The surface of the brick should be brushed free from all dust, dirt and loose particles, and should be wetted to such a degree that water will not be rapidly absorbed from the plaster, but not to such a degree that water will remain standing on the surface when the plaster is applied.

Old brick walls which are to be overcoated should have all loose, friable, or soft mortar removed from joints, and all dirt and foreign matter should be removed by hacking, wire brushing or other effective means. Surfaces that have been painted or waterproofed should be lathed with metal lath before overcoating.

6. *Concrete.*—Monolithic concrete walls should preferably be rough and of coarse texture, rather than smooth and dense, for the application of stucco. Walls of this type should be cleaned and roughened, if necessary, by hacking, wire brushing, or other effective means. The surface of the concrete should be brushed free from all dust, dirt, and loose particles, and should be wetted to such a degree that water will not be rapidly absorbed from the plaster, but not to such a degree that water will remain standing on the surface when the plaster is applied.

7. *Concrete Block.*—Concrete block for stucco walls should be rough and of coarse texture, but not weak or friable. Block should be set with cement mortar joints, which should be raked out or cut back even with surface. Before applying the stucco the surface should be brushed free from all dust, dirt, and loose particles, and should be wetted to such a degree that water will not be rapidly absorbed from the plaster, but not to such a degree that water will remain standing on the surface when the plaster is applied.

MASONRY WALLS

Buildings of hollow terra cotta tile, brick, concrete, concrete block, and similar materials, are particularly well adapted for the application of stucco because of their rigidity. This, however, depends upon good, solid footings or foundation, a requirement which should be met in all types of stucco structures. Masonry walls should also provide a good surface for the bond or adhesion of the stucco, and wherever possible this bond should be insured by some form of mechanical key. For this reason raking out the joints in a brick wall is recommended as an added precaution, and similarly walls of concrete or concrete block should not be too smooth, but preferably rough and of coarse texture.

It is most important that masonry walls be clean before the stucco is applied, as otherwise the bond of the stucco cannot be relied upon to stand the strain set up by moisture and temperature changes. Many a failure of stucco on masonry foundations has been attributed to frost action, when the primary cause of the failure has been lack of care in thoroughly cleaning the walls from dirt. Without secure and positive anchorage under such conditions the stucco cannot endure.

Special attention should be called to the importance of properly wetting the surface of masonry walls just before applying the stucco. Too dry a surface will absorb the water from the fresh plaster coat before the latter has had time to harden properly. On the other hand, a surface completely saturated has lost all its absorptive power, or "suction," a slight degree of which is necessary for best results. A moderate amount of suction tends to draw the fine cement particles into the pores and interstices of the surface; upon this action the bond of the stucco depends. If this bond is to be as strong as possible, the surface should be neither dry nor completely saturated.

Wood lintels over openings in masonry walls should not be used.

When old masonry walls are overcoated special attention is called to the necessity for obtaining thorough cleanliness, a good mechanical bond, and proper suction. When any of these conditions are in doubt the walls should be furred and lathed.

FRAME WALLS

8. *Framing.*—Studs spaced not to exceed 16 inch centers should be run from foundation to rafters without any intervening horizontal members. The studs should be tied together just below the floor joists with 1 x 6 inch boards which should be let into the studs on their inner side, so as to be flush and securely nailed to them. These boards will also act as sills for the floor joists, which, in addition, should be securely spiked to the side of the studs.

9. *Bracing.*—The corners of each wall should be braced diagonally with 1 x 6 inch boards let into the studs on their inner side, and securely nailed to them.

In back-plastered construction in which sheathing is omitted, at least once midway in each story height, the studs should be braced horizontally with 2 x 3 inch bridging set 1 inch back of the face of the studs. This assumes that the studs are 2 x 4 inches. Larger sizes would require correspondingly larger bridging.

In sheathed construction no bridging is necessary.

FRAME WALLS

Good bracing of the frame is important to secure the necessary rigidity. Bridging between the studs at least once in each story height is recommended whether the frame is to be sheathed or not. In the former case the bridging should be of the same size as the studs (usually 2 x 4 inch). In the back-plastered type of construction where sheathing is not used, bridging is required for stiffening the frame, and should be 1 inch less than the studs in depth. It should be placed horizontally, and 1 inch back of the face of the studs, in order that the back-plaster coat may be carried past the bridging without break at this point. Diagonal bracing at the corners of each wall is recommended, especially when sheathing is omitted. Such bracing may be of 1 x 6 inch boards, 6 or 8 feet long, let into the studs on their inner side in order not to interfere with the back plastering or the interior plastering. The length of the corner bracing will, of course, depend to some extent on the location of window or other openings.

The committee feels that fire protection is an important feature of this type of structure, and that some form of fire stop is necessary to develop its full fire-resistive value. Probably the best method is to form a basket of metal lath to occupy the spaces between the studs at the juncture of the floor joists and wall. This should be filled with cement mortar or concrete from the ceiling level to 4 inches above the floor level.

A preliminary report from the Underwriters' Laboratories on back-plastered metal lath and stucco construction with Portland cement indicates that "this finish can be expected to furnish a substantial barrier to the passage of flame into the hollow spaces back of it and to provide sufficient heat insulation to prevent the ignition of the wooden supports to which it is attached for about one hour when exposed to fire of the degree of severity to which stucco-finished buildings are likely to be subjected under average exterior fire exposures."

The committee wishes to recognize the development of metal lumber for frame construction, and believes its merits are such that its use will undoubtedly largely increase. Detailed reference to this form of construction will be made in subsequent additions to this recommended practice.

10. *Sheathing.*—In back-plastered construction the lath should be fastened direct to the studding and back-plastered, and no sheathing is used.

In sheathed construction the sheathing boards should not be less than 6 inches nor more than 8 inches wide, dressed on one or both sides to a uniform thickness of 13/16 inch. They should be laid horizontally across the wall studs and fastened with not less than two 8d nails at each stud.

11. *Inside Waterproofing.*—In back-plastered construction no waterproofing is necessary.

In sheathed construction, over the sheathing boards should be laid in horizontal layers, beginning at the bottom, a substantial paper, well impregnated with tar or asphalt. The bottom strip should lap over the baseboard at the bottom of the wall, and each strip should lap the one below at least 2 inches. The paper should lap the flashings at all openings.

12. *Furring.*—Metal Lath. When furring forms an integral part of the metal lath to be used, then separate furring as described in this paragraph is omitted.

In back-plastered construction galvanized or painted ⅜ inch crimped furring, not lighter than 22-gage or other shape giving equal results, should be fastened direct to the studding, using 1¼ inch x 14-gage staples spaced 12 inches apart.

In sheathed construction galvanized or painted ⅜ inch crimped furring not lighter than 22-gage, or other shape giving equal results, should be fastened over the sheathing paper and directly along the line of the studs, using 1¼ inch x 14-gage staples spaced 12 inches apart. The same depth of furring should be adhered to around curved surfaces, and furring should be placed not less than 1½ inches nor more than 4 inches on each side of and above and below all openings.

Wood Lath. Furring 1 x 2 inches should be laid vertically 12 inches on centers over the sheathing paper and nailed every 8 inches with 6d nails.

13. *Lath.*—Metal lath should be galvanized or painted expanded lath weighing not less than 3.4 lbs. per square yard.

Wire lath should be galvanized or painted woven wire lath, not lighter than 19-gage, 2½ meshes to the inch, with stiffeners at 8 inch centers.

Wood lath should be standard quality, narrow plaster lath 4 feet long and not less than ⅜ inch thick.

When sheathing is used it should be laid horizontally and not diagonally across the studs. The stucco test panels erected at the Bureau of Standards in 1915 and 1916 have demonstrated conclusively that diagonal sheathing tends to crack the overlying stucco by setting up strains in the supporting frame. The result is undoubtedly due to the shrinkage of the sheathing, and whatever benefit might be anticipated from the more effective bracing provided by diagonal sheathing appears to be more than offset by the shrinkage effect. Diagonal sheathing is also less economical than horizontal sheathing, both in material and labor.

Waterproofing of the faces of the studs in back-plastered construction seems to be ineffective and unnecessary, and its elimination is recommended.

The proper type and depth of furring is a question on which information is desired. If metal lath is applied over sheathing and the commonly recommended practice of filling with mortar the space between lath and sheathing is to be followed, there seems to be no good reason for using furring deeper than ⅜ inch. On the other hand, 1 x 2 inch wood furring is widely used for both metal and wood lath, and there are good arguments both for and against this type of furring. The question of the proper length and gage of staples for metal lath is involved with that of furring. The entire subject needs investigation.

Metal lath should be specified by weight rather than by gage, and should be always galvanized or painted. Galvanized lath is a good investment in most cases, and is to be recommended in preference to painted lath, unless the method of applying the stucco is such as to insure complete embedment of the metal, as, for example, in the back-plastered type of construction.

The use of wood lath as a base for stucco finds many advocates and many opponents, but the committee does not feel that it can recommend wood lath for cement stucco. More field and test data should be available before the evidence for and against wood lath can be carefully weighed. Further information is desired in regard to the type of wood lath best suited for cement stucco. In some of the most satisfactory work reported by the committee the lath were of white pine 1 inch wide and ½ inch thick. Both materials and size were here unusual, but the committee is of the opinion that this type of narrow lath is worthy of consideration. For want of information as to the practicability of specifying any particular kind of wood and unusual dimensions, no change is suggested at the present time. It may be stated, however, that nearly all of the test panels of wood lath erected at the Bureau of Standards developed large cracks, in such manner as to suggest that narrower lath (those used were 1⅜ inches wide) with wider keys and heavier nailing would have given better results. The tests also indicate that counter lathing in which the lath are applied lattice fashion produces no more satisfactory results than plain lathing. In view of the much greater cost of counter lathing the committee recommends that reference to this type of application be omitted from specifications.

PREPARATION OF MORTAR

25. *Mixing.*—The ingredients of the mortar should be mixed until thoroughly distributed, and the mass is uniform in color and homogeneous. The quantity of water necessary for the desired consistency should be determined by trial, and thereafter measured in proper proportion.

Machine Mixing. The mortar should preferably be mixed in a suitable mortar-mixing machine of the rotating drum type. The period of machine mixing should be not less than 5 minutes after all the ingredients are introduced into the mixer.

Hand Mixing. The mixing should be done in a water-tight mortar box, and the ingredients should be mixed dry until the mass is uniform in color and homogeneous. The proper amount of water should then be added and the mixing continued until the consistency is uniform.

26. *Measuring Proportions.*—Methods of measurement of the proportions of water should be used which will secure separate uniform measurements at all times. All proportions stated should be by volume. A bag of cement (94 lbs. net) may be assumed to contain 1 cubic foot; 40 lbs. may be assumed as the weight of 1 cubic foot of hydrated lime. Hydrated lime should be measured dry, and should not be measured nor added to the mortar in the form of putty.

27. *Retempering.*—Mortar which has begun to stiffen or take on its initial set should not be used.

28. *Consistency.*—Only sufficient water should be used to produce a good workable consistency. The less water the better the quality of the mortar, within working limits.

PREPARATION OF MORTAR

The importance of proper and thorough mixing of the ingredients of the mortar cannot be too strongly emphasized. Machine mixing is in all cases to be recommended in preference to hand mixing. The use of hair or fiber is considered optional, and when used the method of incorporation should be such as to insure good distribution and freedom from clots. The maintenance of proper and uniform consistency should be insured by measurement of the water as well as of the other ingredients of the mortar. The question of retempering mortar is one which will bear further investigation. At the present time sufficient information is not available to warrant a change in the paragraph on retempering.

14. *Application of Lath.*—Metal Lath. Lath should be placed horizontally, driving galvanized staples 1¼ inch by 14-gage not more than 8 inches apart over the furring or stiffeners. Vertical laps should occur at supports and should be fastened with staples not more than 4 inches apart. Horizontal joints should be locked or butted and tightly laced with 18-gage galvanized wire.

Wood Lath. Lath should be placed horizontally on the furring with ½ inch openings between them. Joints should be broken every twelfth lath. Each lath should be nailed at each furring with 4d nails.

15. *Corners.*—Metal Lath. The sheets of metal lath should be folded around the corners a distance of at least 3 inches and stapled down, as applied. The use of corner bead is not recommended.

Wood Lath. At all corners a 6-inch strip of galvanized or painted metal lath should be firmly stapled over the lath with 1¼ inch x 14-gage galvanized staples.

16. *Spraying.*—Before applying the first coat of plaster, wood lath should be thoroughly wetted, but water should not remain standing on the surface of the lath when the plaster is applied.

17. *Insulation.*—The air space in back-plastered walls may be divided by applying building paper, quilting, felt, or other suitable insulating material between the studs, and fastening it to the studs and bridging by nailing wood strips over folded edges of the material. This insulation should be so fastened as to leave about 1 inch air space between it and the stucco. Care should be taken to keep the insulating material clear of the stucco, and to make tight joints against the wood framing at the top and bottom of the space and against the bridging.

18. *Overcoating.*—Old frame walls which are to be overcoated should be made structurally sound in every respect, and, as far as possible, the general conditions on pages 1 and 2 should be observed; otherwise the recommended practice for frame structures obtains.

19. *Cement.*—The cement should meet the requirements of the standard specifications for Portland cement of the American Society for Testing Materials, and adopted by this Institute. (Standard No. 1.)

20. *Fine Aggregate.*—Fine aggregate should consist of sand, or screenings from crushed stone or crushed pebbles, graded from fine to coarse, passing when dry a No. 8 screen. Fine aggregate should preferably be of silicious materials, clean, coarse, and free from loam, vegetable, or other deleterious matter.

21. *Hydrated Lime.*—Hydrated lime should meet the requirements of the standard specifications for hydrated lime of the American Society for Testing Materials.

22. *Hair or Fiber.*—There should be used only first quality long hair, free from foreign matter, or a long fiber well combed out.

23. *Coloring Matter.*—Only mineral colors should be used which are not affected by lime, Portland cement, or other ingredients of the mortar, or the weather.

24. *Water.*—Water should be clean, free from oil, acid, strong alkali or vegetable matter.

The results of tests and field observations indicate that more attention should be given to the application of lath to exterior surfaces. Cracks frequently develop in stucco over laps or at junctions of metal and wire lath, indicating a weakness at these points. This may be due in part to reduced thickness of the stucco where the lath is lapped, or to insufficient tying and fastening at the joints. The ideal job of lathing would obviously be that in which the lath forms a uniform fabric over the structure, without seams or lines of weakness, and with equal reinforcing value in all directions. The ideal condition cannot be realized, but evidence is at hand to indicate that butted and laced or well-tied horizontal joints are better than lapped joints, and in the case of ribbed lath that carefully locked joints are better than lapped joints. Vertical joints must almost of necessity be lapped, but the joints may be made secure if they occur over supports and are well stapled at frequent intervals.

At the present time the warmth of the back-plastered stucco house in comparison with that of the sheathed house is questioned by some, but the available evidence seems to indicate that where insulation has been provided as specified, generally satisfactory results have been obtained.

Ordinary building paper applied in a double layer is recommended as a satisfactory insulating medium.

In this connection reference may be made to a series of tests conducted in 1919 at the Armour Institute of Technology, Chicago, to determine the relative heat conductivity of various types of walls. These tests indicated that by the use of building paper or quilting the loss of heat through a stucco wall of the back-plastered type was less, under standardized conditions, than the loss through the ordinary wood frame wall, covered with sheathing and drop siding. A complete report of these tests may be obtained on application to the Commissioner, Associated Metal Lath Manufacturers, Chicago, Ill.

The paragraphs relating to materials are sufficiently specific as to the quality of the stucco ingredients. However, reference may be made to the recently developed colorimetric test for detecting the presence of organic matter in sands, a description of which is to be found in the report of Committee C-9, American Society for Testing Materials, 1919.

Hydrated lime should be specified to the exclusion of lump lime, chiefly for the reason that lime which is slaked on the job cannot as a rule be so thoroughly hydrated and so thoroughly mixed in the mortar as the mechanically hydrated product.

29. *Mortar.*—All coats should contain not less than 3 cubic feet of fine aggregate to 1 sack of Portland cement. If hydrated lime is used it should not be in excess of one-fifth the volume of cement. Hair or fiber should be used in the scratch coat only on wood lath, on metal or wire lath that is to be back-plastered, or on metal or wire lath which is applied over sheathing and is separated therefrom by furring deeper than ⅜ inch.

30. *Application.*—The plastering should be carried on continually in one general direction without allowing the plaster to dry at the edge. If it is impossible to work the full width of the wall at one time, the joining should be at some natural division of the surface, such as a window or door.

The first coat should thoroughly cover the base on which it is applied and be well troweled to insure the best obtainable bond. Before the coat has set it should be heavily cross-scratched with a saw-toothed metal paddle or other suitable device to provide a strong mechanical key.

The second coat should be applied whenever possible on the day following the application of the scratch coat. The first coat should be dampened if necessary, but not saturated, before the second coat is applied. The second coat should be brought to a true and even surface by screeding at intervals not exceeding 5 feet, and by constant use of straightening rod. When the second coat has stiffened sufficiently, it should be dry floated with a wood float and lightly and evenly cross-scratched to form a good mechanical bond for the finish coat. The day following the application of the second coat, and for not less than three days thereafter, the coat should be sprayed or wetted at frequent intervals and kept from drying out.

In back-plastered construction the backing coat should preferably be applied directly following the completion of the brown coat. The keys of the scratch coat should first be thoroughly dampened, and the backing coat then well troweled on to insure filling the spaces between the keys and thoroughly covering the back of the lath. The backing coat should provide a total thickness of plaster back of the lath of ⅝ inch or ¾ inch, and should finish about ¼ inch back of the face of the studs.

The finish coat should be applied not less than a week after the application of the second coat. Methods of application will hereinafter be described under "finish."

31. *Two-Coat Work.*—Whenever two-coat work is required, the first coat should preferably be "doubled"—that is, as soon as the first coat is stiff enough it should be followed by a second application of mortar, and this should then be treated as described for the second coat under paragraph 30. The finish should be applied not less than a week after the application of the first coat.

32. *Drying Out.*—The finish coat should not be permitted to dry out rapidly, and adequate precaution should be taken, either by sprinkling frequently after the mortar is set hard enough to permit it, or by hanging wet burlap or similar material over the surface.

33. *Freezing.*—Stucco should not be applied when the temperature is below 32 degrees F., nor under any conditions such that ice or frost may form on the surface of the wall.

MORTAR COATS

Practice varies widely in the mixture and application of stuccos. The use of hair, lime, and waterproofing materials, the variations in the mixtures for the different coats, the number and thickness of the coats, the intervals between the coats, the degree of wetting of the undercoats, and the precautions necessary in protecting the coats from too rapid drying, are details subject to question, and all will stand further investigation. However, the study of the experimental panels at the Bureau of Standards has yielded considerable information on some of these points.

One of the most important indications from these panels is that lean mixtures containing well-graded aggregate give better results than those commonly specified. Mixtures as lean as one part of cement to six or seven parts of graded aggregate have given excellent results in these tests. The committee is of the opinion that the volume change of rich mortars is accountable for much of the unsightly cracking of stuccos, and that no mixture should be used in which the proportion of cement is greater than one part to three parts of fine aggregate.

The effect of hydrated lime in cement stucco has also been given considerable attention, and the conclusion which is forcing itself upon the committee is that hydrated lime does not improve the structure of the stucco, but by imparting better working quality to the mortar reduces the cost of application. On the other hand, there is evidence that not more than 20% of hydrated lime, by volume of the cement, should be added to cement stucco if the best results are to be obtained.

There seems to be no good reason for varying the composition of the different coats, but if a variation is to be specified, the scratch coat should logically be the strongest mixture, followed by a leaner brown coat and a still leaner finish. No greater mistake has ever been made in stucco application than the use of a strong brown coat over a weak base or a weak scratch coat. The not uncommon practice of applying a strong brown coat over a lime mortar scratch coat has been responsible for many stucco failures.

The suggestion that the finish coat should logically be leaner than the undercoats immediately brings up the waterproofing question. There are two fundamental points to be considered in this connection; first, that the lean coat is not necessarily lacking in density, and second, that the waterproofing problem in good cement stucco is not one of overcoming permeability, but rather of reducing absorption. The entire question hinges on absorption, and the evidence at hand indicates that a moderate degree of absorption is a much more preferable condition than a surface covered with craze and map cracks, produced by the use of a too rich or wrongly manipulated finishing coat. Any waterproofing treatment that alters the natural texture and color of the stucco may be dismissed from considera-

tion, and the merit of any integral waterproofing in stucco is exceedingly difficult to determine.

The question as to number and thickness of coats may be best answered by assuming that each coat of stucco has its own particular function. The scratch coat is the first applied, and its purpose is to form an intimate bond and a secure support for the body of the stucco. On metal lath it also serves as a protective coat, and it should therefore be strong and not too lean. The use of hair or fiber is of questionable value. Hair or fiber should not be used when the space back of the lath is to be filled, and is probably not a necessary ingredient in any case. The committee at the present time would sanction its use only in scratch coats on wood lath, or on metal or wire lath that is to be back-plastered, or on metal or wire lath that is applied over furring deeper than ⅜ inch. The thickness of the scratch coat should average about ¼ inch over the face of the lath.

The function of the second coat (commonly called the brown or straightening coat) is to establish a true and even surface upon which to apply the finish. It forms the body of the stucco, and must fill the hollows and cover the humps of the scratch coat. For this reason an average thickness of ⅜ inch to ½ inch will usually be required. The brown and finish coats, or the scratch and brown coats, are sometimes combined in two-coat work, which is permissible when the base upon which the stucco is applied is fairly true and even, or when, on account of cost considerations, the best obtainable finish is not required. It is difficult, however, to obtain a satisfactory finish on a coat which runs ½ inch or more in thickness, since the tendency of a heavy coat to bag and slip is likely to produce an uneven surface.

The finish coat serves only a decorative purpose and has no structural value. Its function is solely to provide an attractive appearance, and any mixture or any method of application that may detract from the appearance, or in any way injure its permanency, should be avoided. Herein lies the argument for lean mixtures, which are more likely to be free from unsightly defects than rich mixtures, and are also more likely to improve in appearance under the action of the weather. The finish coat should be as thin as possible consistent with covering capacity, and may vary from ⅛ to ⅜ inch in thickness, depending upon the type employed.

It is obvious from the foregoing that first-class stucco should be three-coat work, each coat serving its own particular purpose. The bond between the brown coat and the scratch coat needs to be strong in order to carry the weight of the body of the stucco, and for this reason it is now considered preferable to apply the brown coat the day following the application of the scratch coat. Except in dry or windy weather little wetting of the scratch coat should be necessary when the brown coat is to follow within 24 hours. A slight degree of absorption or "suction" in the scratch coat is probably better than complete saturation, for the brown coat, as well as the others, is necessarily mixed with a larger quantity of water than it requires for maximum strength. The removal of a portion of this excess water by

the suction of the undercoat not only improves the quality of the coat, but also insures a better bond by tending to draw the fine particles of the cement into the pores and interstices of the undercoat.

Whereas the interval between the brown coat and scratch coat, as recommended above, is relatively short, the interval before applying the finish coat should be as long as permissible under the conditions of the work. The reason for thus delaying the application of the finish is to enable the body of the stucco to obtain its initial shrinkage and a nearer approach to its final condition of strength and hardness, before being covered with the surface coat. The bond of the latter needs to be intimate rather than of maximum strength, and if the body of the stucco has been allowed to thoroughly set and harden, it may be assumed that there is less liability of volume changes in the undercoats to disturb the finish coat. A week or more should elapse between the application of the brown and finish coats.

The finish coat should be applied over a damp but not saturated undercoat, for excess water is likely to injure the bond seriously. Certain types of finish, such as the wet mixtures used for sand spraying, or for the "spatter dash" finish, may preferably be applied to a fairly dry undercoat, since suction must be depended upon to prevent streakiness and muddy appearance. The fact that finishes of this type applied in this manner may set and dry out with little strength is not serious; they gradually attain sufficient hardness with exposure to the weather.

Curing of the undercoats by sprinkling and protection of finish coats against the sun, wind, rain and frost by means of tarpaulins are always to be recommended. This is not always feasible, however, and the architect should be content to specify and insist upon reasonable precautions. The application of cement stucco in freezing weather should be avoided, and, in fact, temperatures slightly above the freezing point may allow frost to form on a damp wall. The application of stucco under such conditions is likely to result in failure.

FINISH

34. *Stippled.*—The finishing coat should be troweled smooth with a metal trowel with as little rubbing as possible, and then should be lightly patted with a brush of broom straw to give an even, stippled surface.

35. *Sand Floated.*—The finishing coat, after being brought to a smooth, even surface, should be rubbed with a circular motion of a wood float with the addition of a little sand to slightly roughen the surface. This floating should be done when the mortar has partly hardened.

36. *Sand Sprayed.*—After the finishing coat has been brought to an even surface, it should be sprayed by means of a wide, long-fiber brush—a whisk broom does very well—dipped into a creamy mixture of one part of cement to two or three parts sand, mixed fresh at least every 30 minutes, and kept well stirred. This coating should be thrown forcibly against the surface to be finished. This treatment should be applied while the finishing coat is still moist and before it has attained its early hardening—that is, within 3 to 5 hours. To obtain lighter shades add hydrated lime not to exceed 10% of the weight of the cement.

37. *Rough-Cast or Spatter Dash.*—After the finishing coat has been brought to a smooth, even surface with a wooden float and before finally hardened, it should be uniformly coated with a mixture of one sack of cement to 3 cubic feet of fine aggregate thrown forcibly against it to produce a rough surface of uniform texture when viewed from a distance of 20 feet. Special care should be taken to prevent the rapid drying out of this finish by thorough wetting down at intervals after stucco has hardened sufficiently to prevent injury.

38. *Applied Aggregate.*—After the finishing coat has been brought to a smooth, even surface, and before it has begun to harden, clean round pebbles, or other material as selected, not smaller than ¼ inch or larger than ¾ inch and previously wetted, should be thrown forcibly against the wall so as to embed themselves in the fresh mortar. They should be distributed uniformly over the mortar with a clean wood trowel, but no rubbing of the surface should be done after the pebbles are embedded.

39. *Exposed Aggregate.*—The finishing coat should be composed of an approved, selected coarse sand, crushed marble, or granite or other special material, in the proportion given for finishing coats, and within 24 hours after being applied and troweled to an even surface should be scrubbed with a stiff brush and water. In case the stucco is too hard, a solution of one part hydrochloric acid in four parts of water by volume can be used in place of water. After the aggregate particles have been uniformly exposed by scrubbing, particular care should be taken to remove all traces of the acid by thorough spraying with water from a hose.

40. *Mortar Colors.*—When it is required that any of the above finishes should be made with colored mortar not more than 10% of the weight of Portland cement should be added to the mortar in the form of finely ground mineral coloring matter.

A predetermined weight of color should be added dry to each batch of dry fine aggregate before the cement is added. The color and

It is practically impossible to specify in written paragraphs the methods by which successful finishes are obtained. The quality of these depends upon the knowledge and skill of the plasterer, and the specification writer must content himself with a brief description of the several types. In the finishing of stuccos, however, there are certain causes and effects which should be more generally recognized, a brief discussion of which will help to explain the limitation of the commonly used finishes and indicate the methods to be pursued in the attempt to develop better finishes.

In an earlier paragraph the defects resulting from the expansion and contraction of rich mortars have been referred to. The chance of such defects occurring must be greatest in the finish coat, which is directly exposed to the extremes of moisture and temperature variations. The hope of overcoming these defects lies mainly in the use of leaner mixtures, in which the tendency to movement is cut down as the proportion of cement is reduced. The problem therefore is to use less cement and at the same time retain the necessary density by improved gradation of the aggregates. Considerable success has already attended experiments along this line, and even better results are anticipated in the future.

All that may be accomplished in this direction, however, will hardly permit a smooth troweled finish to be used. This treatment produces a concentration of fine material at the surface, which will almost inevitably develop fine cracks. In the course of time these cracks will collect soot and dirt and become conspicuous and unsightly. At best the smooth troweled finish is not to be recommended, and specifications should eliminate all reference to it.

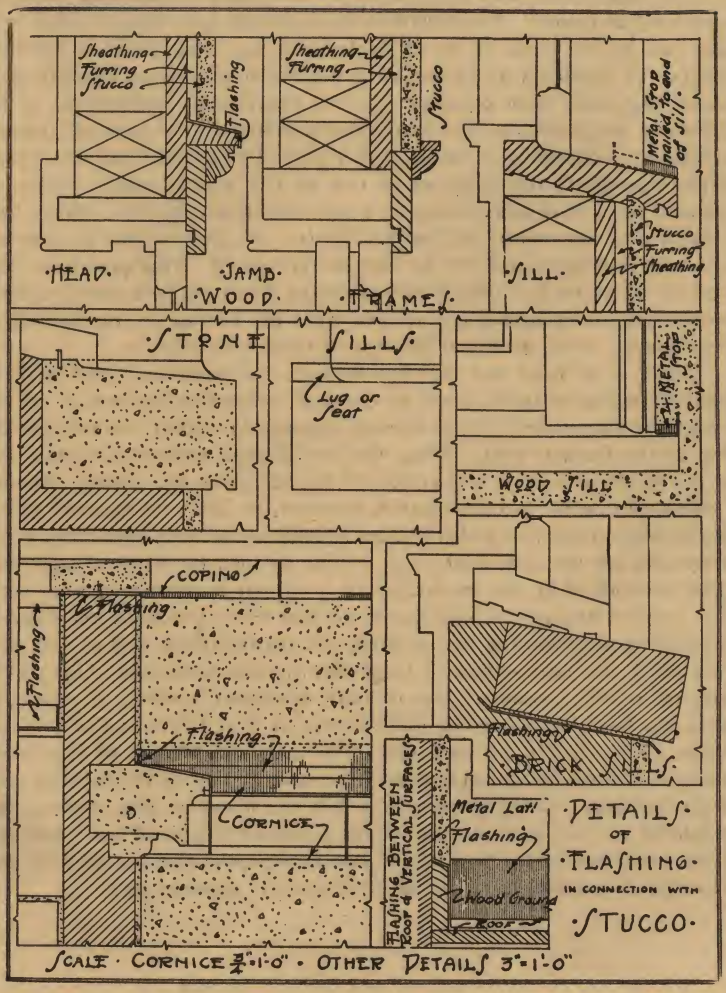
The dash finishes—such as the sand spray, which is obtained by applying a mixture of sand, cement and water with a whisk broom or long-fiber brush, or the spatter dash, which is usually a thin mortar containing coarse sand or stone screenings thrown from a paddle, or the rough-cast, which is a mixture of pebbles and cement grout thrown from a paddle or the back of a trowel—are all relatively rich in cement and all develop fine cracks to a very marked degree, but the rough texture of the surfaces masks these defects, and the type is therefore generally satisfactory and very widely used. The use of these finishes is in general to be recommended, unless the work is done by a stucco specialist, whose skill and experience qualify him to execute the more difficult finishes to be discussed in the following paragraphs.

The chief objection to the dash finishes as above described is their rather cold, unbroken cement color, which may be relieved and improved to a considerable extent by the judicious use of mineral pigments. Another means of varying the monotony of the natural grays and whites of the cement is by the use of the dry dash finishes, in which clean pebbles or stone chips are thrown against the fresh mortar of the finishing coat while it is still soft. When the dry dash is well selected, and the particles thickly and uniformly distributed over the surface, the finish thus obtained is pleasing and possesses decidedly more life and character than the wet dashes.

fine aggregate should be mixed together and then the cement mixed in. The whole should be then thoroughly mixed dry by shoveling from one pile to another through a ¼ inch mesh wire screen until the entire batch is of uniform color. Water should then be added to bring the mortar to a proper plastering consistency.

The sand-float finish deserves special consideration because it promises to be one of the most satisfactory finishes of the future. Due to the use of rich mixtures the sand-float finish has usually developed defects similar to those experienced with the smooth troweled finishes, differing from the latter only in degree. Sand-floated stuccos which have been covered with paint are to be found in every community, and this alone is sufficient evidence of unskillful manipulation of this finish and of the unsatisfactory results that have been obtained. In the experiments carried out at the Bureau of Standards the sand-float finish was found to be most satisfactory on mixtures containing not more than 1 part of Portland cement to 4 parts of fine aggregate, and mixtures as rich as 1:3, with a small addition of hydrated lime, were satisfactory as a rule only when the final floating was delayed until the mortar had well stiffened. In this manner the concentration of fine material in the surface was prevented. This experience confirms the necessity for using leaner mixtures than have been specified heretofore, and for removing the cement from the surface by mechanical or other means, if the sand-float finish is to come into its own.

There is no hard and fast line between the sand-float finish and the exposed aggregate finish, since in the final water-floating process of the former the aggregate is left sufficiently exposed to modify and improve the tone of the finished wall. When the sand-floated surface is further improved by an acid wash the grains of the aggregate are cleanly exposed. It seems preferable in classification, however, to limit the exposed aggregate finishes to those in which coarser aggregates are employed than would be feasible for the sand-float finish. Thus defined, the exposed aggregate finish is obtained by the application of a coarser mortar containing carefully selected and graded aggregates, so that when the latter are exposed by brushing and cleaning the resulting texture resembles that of cast concrete which has been subjected to similar surface treatment. One of the members of the committee has recently developed a stucco of this type which has been applied to the Field House in East Potomac Park, Washington, D. C., over terra cotta tile. The color and texture of this finish, produced entirely by the aggregate, is the same as that of the concrete trim of the building. At the present time only the wings of this structure are completed, but the work thus far marks a distinct step in advance, not only in the treatment of the stucco, but also in the general adaptation of surface-treated concrete to exacting architectural requirements.


Sheathing
Furring
Stucco
Flashing
Sheathing
Furring
Stucco
Metal Strip nailed to end of Sill
Stucco
Furring
Sheathing
HEAD
JAMB
WOOD
FRAME
SILL
STONE SILL
Lug or Seat
METAL STOP
WOOD SILL
COPING
Flashing
Flashing
Flashing
Flashing
BRICK SILL
CORNICE
FLASHING BETWEEN ROOF & VERTICAL SURFACE
Metal Lath
Flashing
Wood Grounds
Roof
DETAILS OF FLASHING IN CONNECTION WITH STUCCO
SCALE · CORNICE 3/4"=1'-0" · OTHER DETAILS 3"=1'-0"

In conclusion, the committee desires to state its conviction that while Portland cement stucco may develop certain small defects which cannot always be guarded against, the product may be depended upon, if applied in accordance with the accompanying recommended practice, to be structurally sound, durable, and capable of giving satisfactory service, with little or no outlay for repairs or maintenance. The committee believes, however, that assurance of satisfactory results in stucco depends largely on the development of stucco specialists, experienced and skilled in this particular art, as distinguished from ordinary plastering. Intelligent and high-class workmanship is so essential to good stucco that only those contractors who have had sufficient experience to establish their own confidence in the product, and who are willing to guarantee their work, should be employed for its application.

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E. D. Boyer,
C. M. Chapman,
Wharton Clay,
J. J. Earley,
J. E. Freeman,
F. A. Hitchcock,
J. B. Orr,
J. C. Pearson, *Chairman.*

Overcoating Old Wooden Structures

Preparation of Original Surface

If the weather-boarding is in poor condition it should be removed, then furring and expanded metal or wire lath applied over the sheathing, to which sheathing paper has previously been fastened. It may be advisable also to tear off the sheathing, in which case the furring can be fastened direct to the studding after bracing between the studs.

Another method is to fasten the furring direct over the weather-boarding, and then apply the metal lath.

In preparation for any of these methods the house should be gone over carefully to determine whether the framework is strong enough and in good enough condition to produce satisfactory results. The stucco brings an additional weight on the framing.

Doors should be looked after, studding inspected, partitions and outside walls lined up and brought into plumb.

Window and Door Frames

Where furring used is so deep that the space back of the lath is not entirely filled with plaster, some provision must be made for extending the old window and door frames to correspond with the increased thickness of the wall. In some cases the plaster is brought over the old frames in such a manner that a recessed window or door opening is made. In case the furring is fastened to the studding, it is not necessary to provide for extending the window and door frames, as the new stucco finish will have the same relations as the old weather-boarding.

Furring, Lathing and Plastering

Follow the foregoing recommended practice for portland cement stucco on frame structures.

Table of Colors to be Used in Portland Cement Stucco

Color Desired	Commercial Names of Colors for Use in Cement	Pounds of Color Required for Each Bag of Cement to Secure	
		Light Shade	Medium Shade
Grays, blue-black and black	Germantown lampblack*	½	1
	Carbon black	½	1
	Black oxide of manganese	1	2
Blue shade	Ultramarine blue	5	10
Brownish-red to dull brick red	Red oxide of iron	5	10
Bright red to vermilion	Mineral turkey red	5	10
Red sandstone to purplish-red	Indian red	5	10
Brown to reddish-brown	Metallic brown (oxide)	5	10
Buff, colonial tint and yellow	Yellow ochre†	5	10
	Yellow oxide		
Green shade	Chromium oxide	5	10
	Greenish blue ultramarine	6	—

* Only first quality lampblack should be used. Carbon black is light and requires very thorough mixing. Black oxide or mineral black is probably most advantageous for general use. For black use 11 pounds of the oxide for each bag of cement.

† Should contain not less than 15 per cent of the oxide.

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